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(72) Inventor: Yoshiisa Narutaki
c/o Optec K.K.
315-1 Miwamachi, Machida-shi, Tokyo

(72) Inventor: Katsutoshi Sato
c/o Optec K.K.
315-1 Miwamachi, Machida-shi, Tokyo

(72) Inventor: Hitoshi Ooura
c/o Optec K.K.
315-1 Miwamachi, Machida-shi, Tokyo

(72) Inventor: Norio Numazawa
c/o Optec K.K.
315-1 Miwamachi, Machida-shi, Tokyo

(72) Inventor: Koichi Hayashi
c/o Optec K.K.
315-1 Miwamachi, Machida-shi, Tokyo

(72) Inventor: Misao Machida
c/o Optec K.K.
315-1 Miwamachi, Machida-shi, Tokyo

(72) Inventor: Shigehiro Kusumoto
c/o Optec K.K.

		315-1 Miwamachi, Machida-shi, Tokyo
(72)	Inventor:	Harumichi Sekikawa
		c/o Optec K.K.
		315-1 Miwamachi, Machida-shi, Tokyo
(71)	Applicant:	Optec K.K.
		315-1 Miwamachi, Machida-shi, Tokyo
(74)	Agent:	Masaru Tsuchiya, Patent Attorney

Specification

1. Title of Invention

Optical transceiver device

2. Claims

1. An optical transceiver device, comprising a large-diameter light-receiving lens, comprising a light-receiving element on the optical axis; a plurality of small-diameter light-transmitting lenses, positioned in a ring shape on the periphery of said light-receiving lens, and each comprising a light-emitting element on the optical axis of each; and, a signal transmission/reception device connected to said light-receiving element and light-emitting elements.

2. The optical transceiver device according to Claim 1, characterized in that said signal transmission/reception device is a data transmission circuit which delivers data signals to said light-emitting elements and a data reception circuit which receives output from said light-receiving elements.

3. The optical transceiver device according to Claim 1, characterized in that said light-receiving element is a position sensor having four output terminals, to detect shifts from an origin in the horizontal or vertical directions of the image-formation point due to the light-receiving lens.

4. The optical transceiver device according to Claim 3, characterized in that said signal transmission/reception device [comprises] a collimating servo device which deflects the optical axis of said light-receiving lens in the vertical and horizontal directions based on the output of said position sensor, to collimate the optical axis on the remote station, and a modulator to send servo light modulated at a prescribed frequency from said light-emitting elements to the remote station.

5. The optical transceiver device according to Claim 4, characterized in that said light-emitting elements are divided into two groups, and that said signal transmission/reception device comprises said modulator, which provides servo modulation signals to one of said groups of light-emitting elements, and a data transmission circuit, which supplies transmission data signals to the other of said groups of light-emitting elements.

3. Detailed Description of the Invention

Industrial Field of the Invention

This invention relates to an optical transceiver device, and in particular to an optimal [device] which is optimal for use in automatic collimation-type optical data communication equipment or automatic collimation-type range-finder equipment (optical distance-measurement equipment) comprising a collimating servo device to collimate the optical axis of an objective lens with a remote station.

Summary of the Invention

[A plurality of] small-diameter light-transmitting lenses are arranged in a ring shape on the periphery of a large-diameter light-receiving lens, to increase the amount of

light transmitted and the light-receiving ability, and to reduce the degree of parallelism of the transmission and reception optical axes, in a compact optical transceiver device with longer optical transmission and reception distances.

Prior Art

In civil engineering, harbor engineering, coastal engineering and other areas, a system is required to measure, from a fixed position, the position or distance of a bulldozer, dredging ship, ship berth, or other mobile object.

In the past, systems have been known which provide optical distance-measurement equipment at either the fixed position or the mobile object, and a reflector (a corner-cube prism or similar) at the other, and use an automatic collimating method to cause the optical axes to coincide, so that even if the berth or other mobile object moves, position measurement can be performed without difficulty (see for example Japanese Utility Model Publication No. 59-8221).

Publicly-known automatic collimating-type optical distance-measurement equipment comprises a servo system which has a collimating servo optical axis parallel to the optical axis of the distance-measurement device; collimating servo light from the measurement point is received by a light-receiving element split into four parts (a photodiode or similar with light-receiving surface divided into four quadrants, horizontally and vertically), the output is fed back to horizontal and vertical deflection motors, and the servo light is made to form an image at the origin of the light-receiving element.

Distance data from distance-measurement equipment is used at a ship berth, so that normally a configuration is adopted in which the distance-measurement equipment is placed at the ship berth, and a reflector is placed on the land side.

If a corner-cube prism is used as the reflector, then even if fluctuations as great as 30° in the optical axis of the prism occur, the optical path between distance-measuring equipment and reflector, and the reflection optical path, will not change at all. Hence if a configuration is adopted in which a corner-cube prism is placed on the ship berth side, and distance-measuring equipment is placed on land, stable distance measurement can be performed without influence from the pitching and rolling of the ship. However, in this case the distance measurement data on the land side must be transmitted to the ship berth side.

In addition, measurement data, air temperature, air pressure, and other meteorological correction data and similar must be transmitted from the ship berth side to the land side, or vice-versa. Also, when the operating equipment on the ship berth or elsewhere is unmanned, position control calculated based on position-measurement values, and instruction data for operation control, must be transmitted to the unmanned equipment.

Thus data transmission has been indispensable for a precise marine operating system; however, provision of a communication channel and signal transmission/reception equipment specifically for this purpose would be extremely costly. However, it is possible that an optical path for a collimating servo may be utilized as an optical data communication channel.

Problems to be Solved by the Invention

Among optical data transceiver devices and automatic collimating optical transceiver devices such as described above, devices are known in which the transmission optical system and reception optical system are positioned with the same axis, and in which the two have two parallel axes. In the former case, the objective lens (focusing lens for light reception) and the collimator lens for light transmission are a single lens, and only a single lens barrel is needed, so that such a design is suitable for compact, lightweight equipment. However, the optical axis must be divided into light-transmission and light-reception [axes] behind the lens, and a semi-transmissive mirror or other analysis means with large insertion loss becomes necessary; also, if the light transmission output is increased, obstruction due to stray light in the lens barrel tends to occur. Hence such a device is not suited to optical transmission and reception over long distances.

On the other hand, in a dual parallel-axis design the lens barrels are separate, so that there is no obstruction due to stray light even if the optical transmission output is increased, and the optical reception efficiency is also good, so that in principle optical transmission and reception over long distances is possible.

However, a dual parallel-axis design is larger and heavier, and lacking in portability. Further, if the transmission and reception optical axes are not made completely parallel, the widening between the optical axes due to the angular difference between the optical transmission and reception axes increases with increasing distance, so that optical transmission and reception between the two stations becomes difficult. If an angle of divergence is added to the optical transmission beam, the [requirement] of parallelism of the transmission and reception optical axes is relaxed somewhat; but as a result of divergence the amount of light at the remote station (receiving side) is greatly reduced, so that again it is difficult to transmit and receive light over long distances.

This invention was devised in consideration of the above problems, and has as an object the provision of [a device] which can be configured for compactness and light weight, yet enables optical transmission and reception over long distances.

Means to Solve the Problems

The optical transceiver device of this invention comprises a large-diameter light-receiving lens 13, comprising a light-receiving element 15 on the optical axis; a plurality of small-diameter light-transmitting lenses 12, positioned in a ring shape on the periphery of the above light-receiving lens 13, and each comprising a light-emitting element 14 on the optical axis of each; and, a signal transmission/reception device connected to said light-receiving element and light-emitting elements.

Action

In a comparatively compact configuration, the light-receiving lens can be made large and the light-receiving sensitivity increased, and at the same time the optical transmission output can easily be increased. Numerous light-transmitting lenses are positioned about the light-receiving optical axis in a concentric circle, so that a single averaged light-transmission optical axis can be considered. Even if there is some angular deviation between the light-receiving optical axis and the several light-transmitting optical axes, the angular deviations are cancelled by averaging over several [axes], and

the averaged light-transmitting axis coincides with the light-receiving axis. Hence the parallelism of the transmitting and receiving axes may be comparatively low, so that manufacturing is facilitated, and the limit to the distance for optical transmission and reception is extended.

Embodiments

Fig. 1 is a block diagram of the entirety of an optical distance measurement system for marine operations, illustrating one embodiment of this invention. Fig. 2 and Fig. 3 are front views of the distance-measurement equipment at the land station and the ship berth station. Each station comprises an automatic collimating device 2 provided on a base 1; on the land station is provided an optical distance-measurement device 3, and on the ship berth station a reflector 4, forming parallel optical axes with each of the collimating devices 2. The optical distance-measurement device 3 comprises an objective lens 5 (light transmitting/receiving lens); the reflector 4 comprises a corner-cube prism 6.

The collimating devices 2 comprise a horizontal support arm 7 which rotates freely within the horizontal plane, and a vertical support arm 8 which rotates freely within a vertical plane; these are driven by an X-axis gear motor 9 and a Y-axis gear motor 10, respectively. On the vertical support arm 8 is mounted an optical transmission/reception unit 11, comprising light-transmitting lenses 12 and a light-receiving lens 13. LEDs or other light-emitting elements 14 are positioned at the focal points of the light-transmitting lenses 12, and a photodiode or other light-receiving element 15 is positioned at the focal point of the light-receiving lens 13. The optical transmission/reception units 11 of the land station and the ship berth station comprise entirely the same optical systems.

As shown in the front view of the optical transmission/reception unit 11 of Fig. 4, the light-receiving lens 13 is of comparatively large diameter, and a plurality of light-transmitting lenses 12 are arranged on its periphery in a ring shape along a concentric circle. Hence weak light transmitted from an extremely distant point can be condensed with high sensitivity by the large-diameter light-receiving lens 13. And by transmitting light from numerous small-diameter light-transmitting lenses 12, the amount of transmitted light can be easily increased. Hence transmission and reception of light over long distances is possible using a comparatively compact optical system.

As the optical transmission and reception distance increases, the angular difference between the transmission optical axis and the reception optical axis becomes a problem. In this embodiment, numerous light-transmitting lenses 12 are arranged in a ring shape about the optical axis of the light-receiving lens 13, so that a single transmission optical axis which is the geometric average can be considered. This average transmission optical axis coincides with the reception optical axis, so that even if the degree of parallelism of transmission and reception is relaxed somewhat, the angular differences are averaged, and on average the axis coincidence is increased. Hence even if an axis adjustment mechanism or similar is not provided, good long-distance performance can be obtained with comparative ease.

In general a transmitted optical beam has an angle of divergence α expressed by

α = (area of light-emitting element)/(focal length of light-transmitting lens)

Hence numerous transmitted light beams arrive at the remote station as a single light ray.

As shown in Fig. 4, the light-transmitting lenses 12 are divided into a servo group, and a data transmission group (indicated by shading). In Fig. 1, the sinusoidal output (5 kHz) of an oscillator 18 is supplied, via a driving circuit 19, to the light-emitting elements 14 positioned at the focal points of the respective servo light-transmitting lenses 12. By this means, amplitude-modulated collimating servo light passes through the light-transmitting lenses 12 and is incident on the light-receiving lens 13 of the collimating optical system on the ship berth side, and is focused on the light-receiving element 15 positioned at the focal point.

On the other hand, amplitude-modulated collimating servo light is similarly transmitted from the light-emitting elements 14 for transmission in the optical transmission/reception unit 11 on the ship berth side, through the light-transmitting lenses 12, toward the land station, and is received by the light-receiving element 15 via the light-receiving lens 13 of the land station.

The collimating servo light transmitted from the optical transmission/reception unit 11 of the land station to the ship berth station is reflected by the reflector 4 of the ship berth station and returns to the light-receiving system of the [land] station, to become an obstructing signal in the servo system. In order to prevent this, the amplitude modulation frequency of the collimating servo light at the ship berth station is set to 3 kHz, differing from the 5 kHz amplitude modulation frequency of the land station. As described below, the land station servo system performs frequency selection of the received servo signal, responds only to the servo light from the ship berth station (3 kHz), and so eliminates obstruction by its own returning light (5 kHz).

The light-receiving element 15 may for example be a two-dimensional (X-Y plane) semiconductor position detection element which detects the position of a light spot relative to an origin. This element has a structure in which four electrodes (two X-Y pairs) are provided on the four edges of a photodiode having a square light-receiving surface, and the electric charge occurring at the position at which the light spot is incident, as a photocurrent, is voltage-divided by the resistive layer of the light-receiving surface in inverse proportion to the distance to each of the electrodes, and is thus captured by the several electrodes.

In Fig. 1, the outputs of each of the electrodes of the light-receiving element 15 are frequency-selected (tuned to 3 kHz) by a tuning circuit 20 comprising a tuning transformer 20a and a tuning capacitor 20b, then pass through amplifiers 21a to 21d, are synchronously detected by the detectors 22a to 22d, and converted into DC levels corresponding to the position at which light was received. After the four detection outputs, as vertical (U,D) and horizontal (L,R) position detection signals, are converted into digital signals by an A/D converter 23, they are input via a bus 24 to a microprocessor within the system controller 24.

Within the microprocessor, the X-Y coordinate position of the received light spot on the light-receiving surface is calculated from the U, D, L, R position detection data. The system controller 25 delivers driving pulses to the motor driving circuits 26X, 26Y for each axis based on this coordinate position data, and by this means the X-axis and Y-axis gear motors 9, 10 are driven. The servo loop from the light-receiving element 15 to

the motors 9, 10 operates such that the received light spot on the light-receiving element 15 is positioned at the origin of the X-Y coordinates on the light-receiving surface. In the state in which the servo system is operating, the optical axes of the collimating optical systems of the land station and ship berth station coincide. As a result, the optical axis of the optical distance-measurement device 3 of the land station is correctly directed toward the reflector 4 of the ship berth station, so that distance measurement is possible.

A similar collimating servo system is provided at the ship berth station, so that the two opposing stations can perform mutual collimation.

Means are provided for fine adjustment of the direction of the optical axis of the collimating device 2 of each station. In Fig. 1, this fine adjustment means is a joystick 27; but fine-adjustment knobs may be provided for the gear systems of the motors 9, 10 for the X and Y axes. A voltage output corresponding to operation of the joystick 27 in the X and Y directions is sent to the system controller 25 via the A/D converter 28, and fine adjustment driving pulses are delivered to the motor driving circuits 26X, 26Y from the controller 25 to fine-adjust the motors 9, 10. Hence the operator peers through a collimating telescope of the optical distance-measurement device 3, for example, while operating the joystick 27 to perform collimation with the remote station. When collimation is completed, pressing the servo start button causes the above-described collimating servo to be started, and thereafter automatic collimation is performed in response to rocking and movement of the ship berth.

Shifts in the optical axis detected by the light-receiving element are displayed by a display device 29 connected to the bus 24 of the system controller 25. The display device 29 may for example be a CRT, and shows the deviation from the origin of the X-axis (horizontal direction) and Y-axis (vertical direction) of the spot 29a in the XY coordinate display of the CRT. The CRT bar display 29b shows the total received optical level (reception strength) of the light-receiving element 15.

In the collimated state, when the circuit unit 30 of the optical distance-measurement device 3 operates, emission of measurement light at approximately 15 MHz (AM) and reception of light reflected from the measurement point are performed by the optical transmission/reception unit 31 placed at the focal point of the objective lens 5. The difference in phase of the emitted light and received light is measured by the circuit unit 31, and based on this the distance between stations is calculated. The distance data is transmitted to the system controller 25 via the interface 32 and bus 24, and is then sent to the ship berth station via a modem 33.

The optical transmission path and optical reception path for automatic collimation between the land station and ship berth station can also be used as a bidirectional optical communication channel. That is, output from the transmission terminal S of the modem 33 is input to an FM modulator 34, and a carrier at 5.5 MHz is frequency-modulated by the transmission data. The FM output is applied to the light-emitting elements 14' for transmission via the driving circuit 35. The transmission data light from the light-emitting elements 14' is sent to the ship berth station via the light-transmitting lens 12.

On the other hand, the ship berth station similarly comprises a modem 33 and light-emitting elements 14' for transmission; transmission data is transmitted on the light-reception servo path of the land station. Here, for reasons similar to those for the above-

described collimating servo system, the transmission light FM carrier from the ship berth station is at 5 MHz, differing from the 5.5 MHz carrier frequency of data transmitted from the land station. By this means, self-crosstalk on the land station side, arising from the existence of the reflection optical path of the distance-measurement equipment 3, is eliminated. Data transmitted from the ship berth station is, for example, data for correction for physical conditions in distance measurement, such as the air pressure and temperature.

Data-carrying light sent from the ship berth station is received, together with servo light, by the light-receiving element 15 via the light-receiving lens 13. Data signals are separated from servo signals and captured from the anode of the planar diode comprised by the light-receiving element 15. Current is provided, via the primary windings 37a of a transformer 37, from a power supply line provided with a decoupling capacitor 36 to the anode A of the above planar diode. If the inductance of this primary windings 37a is approximately 1 μH, then for a 5 kHz servo signal, the impedance is less than 0.03 Ω, and the insertion loss can be ignored. Hence by utilizing the decoupling capacitor 36, the direct current, unmodulated by the servo frequency, can be supplied to the anode A of the light-receiving element 15.

On the other hand, for a 5 MHz FM data signal, the impedance of the primary windings 37a is approximately 30 Ω, and the amount of the insertion loss can be extracted from the secondary windings 37b. The extracted data signal is delivered to the FM demodulator 40 via the amplifier 39. As already explained, in order to eliminate the self-crosstalk of the 5 MHz transmission data signal, a tuning capacitor 38 is connected to the secondary windings 37b of the transformer 37, and tuned to the 5 MHz reception data signal.

Output from the FM demodulator 40 is input to the reception terminal R of the modem 33, and after decoding is sent to the system controller 25. At the system controller 25, the received data is used to perform corrections to distance measurement data or for other purposes.

Fig. 5 shows examples of the driving circuits of the LEDs or other light-emitting elements 14, 14' connected to the light-transmitting lenses 12. In (A), corresponding to the embodiment of Fig. 1, the light-emitting elements 14, 14' divided into groups are connected in parallel by groups, and are driven by the oscillator/driving circuit 18, 19 and modulator/driving circuit 34, 35. In (B), there is no collimating servo system, for example in a case in which data is transmitted and received only between fixed stations; all the light-emitting elements 14 are connected in parallel, and each element is driven by the output of the modulation/driving circuit 42, which takes as input the transmission data. In both cases A and B, the light-emitting elements 14 may be connected in series.

Fig. 6(A) shows another example of the driving circuit for the light-emitting elements 14; transmission data signals and servo signals are supplied to the modulation/driving circuit 42, are submitted to multiplexing and modulation, and are used to drive the parallel-connected light-emitting elements 14. The servo light (5 kHz AM) and data light (5.5 MHz FM) are multiplexed with 50% modulation each in the amplitude direction, and are optically transmitted.

Fig. 7 shows an LED with lens which can be used as a light-transmitting lens 12 and light-emitting element 14 in Fig. 1. This LED comprises a lens 43, and so a plurality of such LEDs can be arranged directly in a ring shape about the light-receiving lens 13. Commercial products with divergence angles of approx. 5°, 12° and 30° can be obtained, so that an appropriate product can be selected according to the distance [and] performance required. Combination with a light-transmitting lens 12 may be possible. It is also easy to increase the number of light-emitting elements 14.

Fig. 8 shows another example of arrangement of the optical transmission/reception unit lenses. In this example, the objective lens 5 of the optical distance-measurement device is arranged in a separate lens barrel alongside the light-receiving lens 13 with axes parallel. Small-diameter light-transmitting lenses 12 are arranged substantially in a ring shape about each of the lenses 13, 5, and are used for transmission of servo light and data light. One or a plurality of light-transmitting lenses 12 may be used for transmission by the optical distance-measurement device (15 MHz, AM).

Fig. 9 shows the optical system for an example in which the servo optical system is also the optical system of the optical distance measurement device. The servo light is transmitted from a plurality of light-emitting elements 14 via the light-transmitting lenses 12, arranged in a ring shape. One of the light-emitting elements 14 is used as the light source for the optical distance measurement device, and sends light from the light-transmitting lens 12 toward the reflector of the ship berth station. Servo light from the ship berth station (5 kHz, AM) and distance-measurement light reflected from the reflector (15 MHz, FM) are condensed by the large-diameter light-receiving lens 13, and an image is formed on the light-receiving element 15 (position sensor), and at the same time is incident on the light-receiving element 45 of the optical distance-measurement device via a semi-transmissive mirror 44 inserted in the image-formation space. Hence in this example, the collimating servo optical system and optical axis of the optical distance-measurement device coincide (are common), so that an axis adjustment mechanism to render the two optical axes parallel is unnecessary.

The servo light and distance-measurement light have different modulation frequencies, so that by providing means for frequency selection in the processing circuitry, mutual interference can be prevented. In order to reduce the insertion loss of the semi-transmissive mirror 44, the wavelengths of the servo light and distance-measurement light may be divided into, for example, 900 nm and 1100 nm, and in place of a semi-transmissive mirror 44, a wavelength-cutoff filter or dichroic mirror may be used which efficiently reflects wavelengths of 1100 nm and greater, and transmits lower wavelengths with no loss.

Advantageous Result of the Invention

As explained above, in this invention a configuration is adopted in which numerous small-diameter light-transmitting lenses are arranged in a ring shape about the periphery of a large-diameter light-receiving lens 13, so that the light-reception sensitivity and optical transmission output can both be increased, and optical transmission and reception over longer distances is possible, even with a compact optical system. The geometric average of the numerous transmission optical axes coincides with the reception

optical axis, and by averaging over a large number, the [requirement] of parallelism of the transmission and reception optical axes is relaxed. Hence no axis adjustment mechanism is necessary, the apparent optical axis parallelism can be improved, and the optical transmission and reception performance over long distances can be further improved using a simple device construction.

4. Brief Description of the Drawings

Fig. 1 is an overall block diagram of an optical distance measurement system for marine operations, illustrating one embodiment of this invention; Fig. 2 and Fig. 3 are front views of the distance-measurement equipment at the land station and the ship berth station, respectively; Fig. 4 is a front view of an optical transmission/reception system, showing an example of the arrangement of light-transmitting and light-receiving lenses; Fig. 5 is a diagram of the driving circuit for the light-emitting elements; Fig. 6 is a circuit diagram and waveform diagram showing another example of the driving circuit of the light-emitting elements, and a waveform of optical transmission signals; Fig. 7 is a diagram showing in summary an LED with lens used as a light-emitting element and light-transmitting lens; Fig. 8 is a front view of an optical system, showing another example of the arrangement of light-transmitting and light-receiving lenses; and, Fig. 9 is a diagram showing in summary the optical system of an example in which the servo optical system and distance-measurement optical system have a common optical axis.

In the figures, the following symbols are used:

2 Automatic collimating device

3 Optical distance-measurement device

4 Reflector

5 Objective lens

6 Corner-cube prism

7 Horizontal support arm

8 Vertical support arm

9 X-axis gear motor

10 Y-axis gear motor

11 Optical transmission/reception unit

12 Light-transmitting lens

13 Light-receiving lens

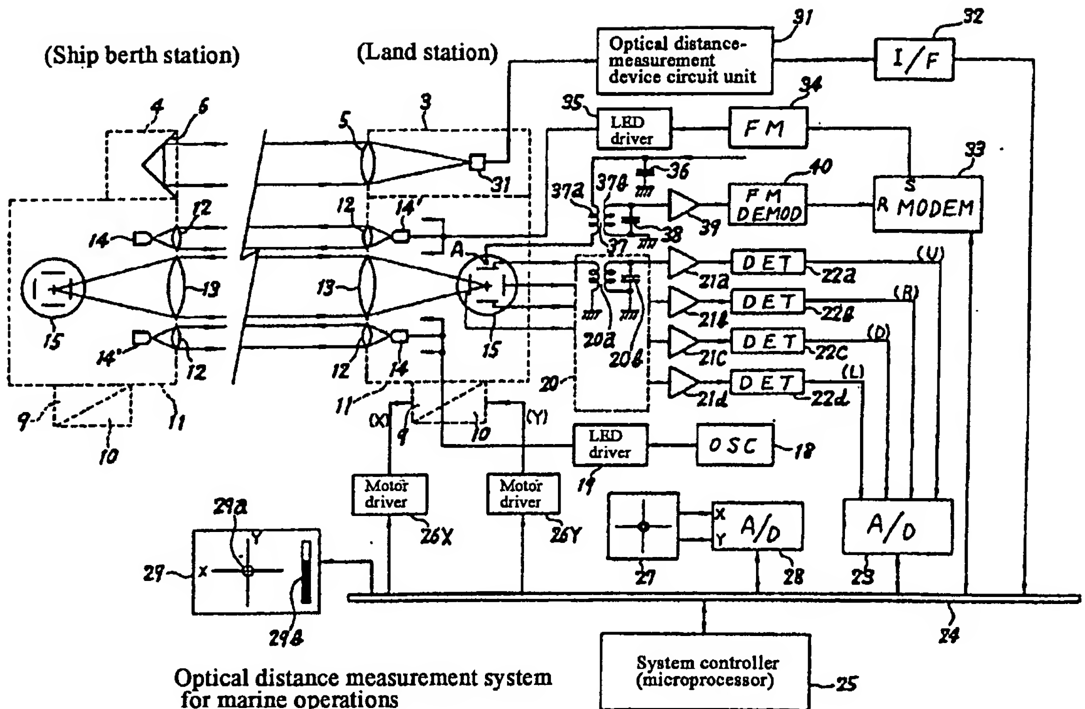
14 Light-emitting element

15 Light-receiving element

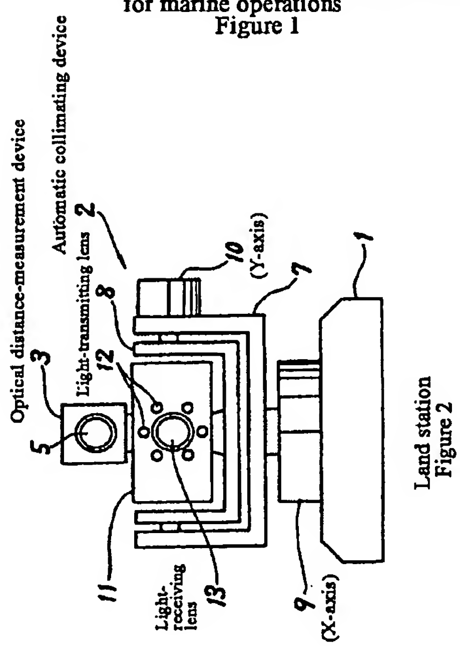
33 Modem

34 FM modulator

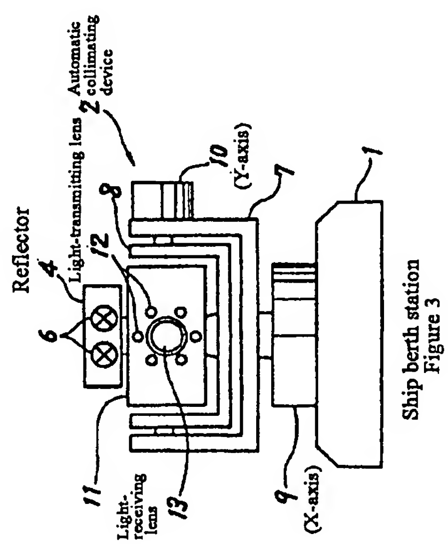
Agent: Masaru Tsuchiya



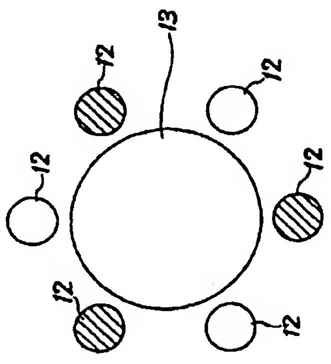
Optical distance measurement system for marine operations
Figure 1



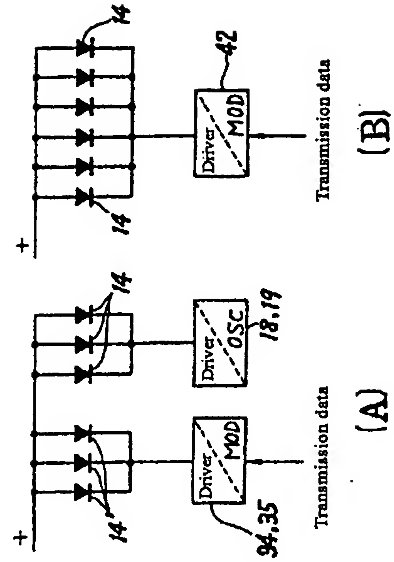
Land station
Figure 2



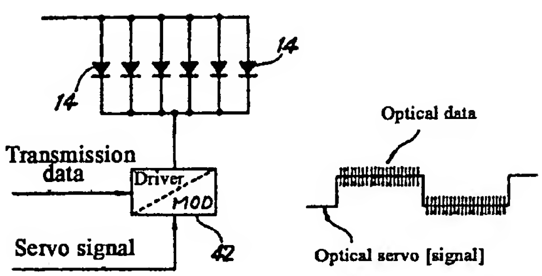
Ship berth station
Figure 3



Light transmission/reception object lenses
Figure 4

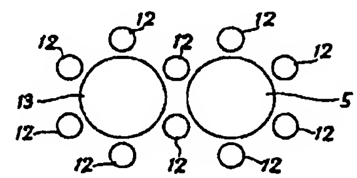


LED driver circuit
Figure 5

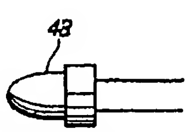


(A) (B)

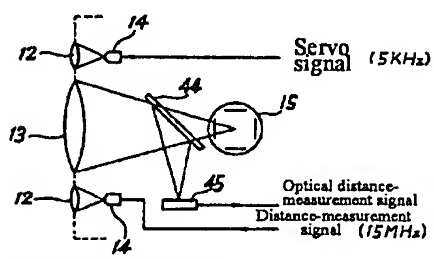
Multiplexing and modulation method
Figure 6



Light transmission/reception lenses
Figure 8



LED with lens
Figure 7



Collimating servo system
and optical distance-measurement system
(common optical axis)
Figure 9

⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　昭63-215125

⑤Int.Cl.⁴　識別記号　庁内整理番号　㊸公開　昭和63年(1988)9月7日
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審査請求　有　発明の数 1　（全8頁）

㊹発明の名称　送受光装置

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㉒出　願　昭62(1987)3月3日

⑫発明者　鳴瀧　能功　東京都町田市三輪町315－1　株式会社オプテック内
⑫発明者　佐藤　勝利　東京都町田市三輪町315－1　株式会社オプテック内
⑫発明者　大浦　一人司　東京都町田市三輪町315－1　株式会社オプテック内
⑫発明者　沼沢　典夫　東京都町田市三輪町315－1　株式会社オプテック内
⑫発明者　林　孝一　東京都町田市三輪町315－1　株式会社オプテック内
⑫発明者　町田　操　東京都町田市三輪町315－1　株式会社オプテック内
⑫発明者　楠本　恵洋　東京都町田市三輪町315－1　株式会社オプテック内
⑫発明者　関川　晴道　東京都町田市三輪町315－1　株式会社オプテック内
⑪出願人　株式会社オプテック　東京都町田市三輪町315－1
⑭代理人　弁理士　土屋　勝

明　細　書

1．発明の名称

送受光装置

2．特許請求の範囲

1、光軸上に受光素子を備える大口径の受光レンズと、上記受光レンズの周囲に環状に複数個配置され且つ夫々の光軸上に発光素子を備える小口径の送光レンズと、上記受光素子及び発光素子に接続された受発信装置とを備える送受光装置。

2、上記受発信装置が、上記発光素子にデータ信号を導出するデータ送信回路及び上記受光素子からの出力を受けるデータ受信回路であることを特徴とする特許請求の範囲第1項に記載の送受光装置。

3、上記受光素子が、受光レンズによる結像点の原点からの上下左右方向のずれを検出するための4つの出力端子を有する位置センサであることを特徴とする特許請求の範囲第1項に記載の送受光装置。

4、上記受発信装置が、上記位置センサの出力に基いて上記受光レンズの光軸を水平及び垂直方向に偏向させ、光軸を相手局に視準させる視準サーボ装置及び、上記発光素子から相手局に向けて所定周波数で変調されたサーボ光を送出するための変調器であることを特徴とする特許請求の範囲第3項に記載の送受光装置。

5、上記発光素子が二つのグループに分けられ、上記受発信装置が上記発光素子の一方のグループにサーボ用変調信号を供給する上記変調器及び上記発光素子の他のグループに送信データ信号を供給するデータ送信回路を備えることを特徴とする特許請求の範囲第4項に記載の送受光装置。

3．発明の詳細な説明

〔産業上の利用分野〕

本発明は送受光装置に関し、特に対物レンズの光軸を相手局に視準させる視準サーボ装置を備える自動視準式光データ通信装置や自動視準式測距

装置（光波距離計）に用いて最適なものである。

〔発明の概要〕

大口径の受光レンズの周囲に小口径の送光レンズを環状に配して、送光量及び受光能力を増強すると共に、送受光軸の平行度を軽減し、もって小型軽量でありながら送受光距離を長くした送受光装置である。

〔従来の技術〕

土木工事、港湾工事、沿岸工事等において、ブルトーザー、浚渫船、作業船台等の移動体の位置又は距離を固定位置から計測するシステムが求められている。

従来、固定位置及び移動体の一方に光波距離計、他方に反射器（コーナキューブプリズム等）を設け、これらの光軸をお互いに一致させる自動視準式にして、船台等の移動体が揺動しても支障無く位置計測ができるようにしたシステムが知られている（例えば実公昭５９－８２２１号公報）。

公知の自動視準式光波距離計は、距離計と平行な視準サーボ用光軸を有し、測定点からの視準サーボ光を４分割受光素子（受光面を水平、垂直の４象限に分割したホトダイオード等）で受けて、その出力を水平、垂直の首振りモータにフィードバックして、受光素子の原点にサーボ光を結像させるようなサーボ系を備えている。

距離計による測距データは船台側で使用されるので、通常は船台側に距離計が置かれ、陸地側に反射器を置く構成が採用されている。

反射器としてコーナキューブプリズムを用いると、プリズムに３０°程の光軸変動が生じても、距離計と反射器との間の放射光路及び反射光路は全く変化しない性質がある。従って船台側にコーナキューブプリズムを置き、陸上に距離計を置く構成であれば、船のピッチングやローリングに影響されない安定な測距ができる。ところがこの場合には陸上側の測距データを船台側に伝送しなければならない。

更に測定データや気温、気圧等の気象状況補正データ等を船台側から陸上へ又はその逆に伝送する必要もある。また船台等の作業装置が無人の場合、位置測定値を基に計算された位置制御や作業制御の指令データを無人装置に伝送しなければならない。

このように高度な海洋作業システムではデータ伝送システムが不可欠になっているが、そのために通信路及び受発信装置を専用に設けるのは非常にコスト高になる。そこで視準サーボ用の光路を光データ通信路として利用することが考えられる。

〔発明が解決しようとする問題点〕

上述のような光データ送受装置や自動視準用送受光装置では、送光光学系と受光光学系とが同軸配置されているものと、両者が平行二軸を成すものとが知られている。前者では対物レンズ（受光用集光レンズ）と光送出用コリメータレンズとが共用され、鏡筒も一つでよいから、軽量小型化に適す。しかしレンズ後方で光軸を送光／受光に分割する必要があり、半透鏡等の挿入損の大きい分光手段を必要とし、また送光出力を増強すると、鏡筒内で迷光による妨害が発生し易い。従って遠距離の送受光には適さない。

一方、平行二軸形は、鏡筒が別になるので送光出力を増強しても迷光による妨害が無く、また受光能率が良いので、原理的には遠距離の送受光が可能である。

しかし平行二軸形は、大型で重量が大となり、携帯性に欠ける。しかも送受光軸を完全に平行にしないと、距離が遠くなるに従って送光と受光との角度差による光軸の開きが大きくなり、二局間での送受光が困難になる。送光ビームに発散角を付けると送受光軸の平行度は或る程度緩和されるが、発散によって相手局（受光側）の光量が著しく低下するので、やはり遠距離の送受光が困難になる。

本発明は上述の問題にかんがみ、小形、軽量に構成でき、しかも遠距離の送受光を可能にすることを目的とする。

〔問題点を解決するための手段〕

本発明の送受光装置は、光軸上に受光素子15を備える大口径の受光レンズ13と、上記受光レンズ13の周囲に環状に複数個配置され且つ夫々の光軸上に発光素子14を備える小口径の送光レンズ12と、上記受光素子及び発光素子に接続された受発信装置とを備える。

〔作用〕

比較的コンパクトな構成で、受光レンズを大きくして受光感度を高めると共に、送光出力を容易に増強することができる。多数の送光レンズが受光光軸の回りの同心円に沿って配列されるので、平均的な1本の送光光軸を考えることができる。受光光軸と個々の送光光軸との間で幾分の角度ずれがあっても、多数の平均により角度差が相殺され、平均的な送光光軸が受光光軸と合致する。従って送／受の軸平行性が比較的低くてよく、製造が容易で、しかも送受光の距離限界が延びる。

〔実施例〕

第1図は本発明の一実施例を示す海洋作業用光測距システムの全体のブロック図で、第2図及び第3図は陸上局及び船台局の各測距装置の正面図である。各局は基台1上に設けられた自動視準装置2を備え、各視準装置2と平行光軸を成して陸上局には光波距離計3、船台局には反射器4が夫夫設けられている。光波距離計3は対物レンズ5（送受光レンズ）を備え、反射器4はコーナキューブプリズム6を備えている。

視準装置2は、水平面内で回動自在の水平架腕7及び垂直面内で回動自在の垂直架腕8を備え、夫々X軸ギヤモータ9及びY軸ギヤモータ10によって駆動される。垂直架腕8上には、送光レンズ12及び受光レンズ13を備える送受光ユニット11が取付けられている。送光レンズ12の焦点にはLED等の発光素子14が配置され、受光レンズ13の焦点にはフォトダイオード等の受光素子15が配置されている。なお陸上局及び船台局の送受光ユニット11は全く同一の光学系を備えている。

第4図の送受光ユニット11の正面図に示すように、受光レンズ13は比較的大口径であり、その周囲の同心円に沿って複数の送光レンズ12が環状に配置されている。従って非常に遠方からの弱い送信光を大口径の受光レンズ13により高感度で集光することができる。また多数の小口径の送光レンズ12から送光することにより、送光量を容易に増強することができる。従って比較的コンパクトな光学系でもってかなりの遠距離の送受光が可能となる。

送受光距離が遠くなると、送光光軸と受光光軸の角度差が問題になる。実施例では、送光レンズ12が受光レンズ13の光軸の回りに環状に多数配列されているので、幾何的平均の一本の送光光軸を考えることができる。この平均的送光光軸は受光光軸と合致し、送／受の平行度が多少緩くても、相互の角度差が平均化され、平均的には同軸度が高まる。よって調軸機構等を設けなくても、比較的容易に長距離性能が得られる。

なお一般に送光ビームは、

$$\alpha = \frac{\text{発光素子面積}}{\text{送光レンズの焦点距離}}$$

で表される発散角αを有しているので、多数の送光ビームが一つの光束となって相手局に到達する。

第4図に示すように送光レンズ12は、サーボ用のグループとデータ送信用のグループ（斜線で示す）とに分けられている。第1図において、サーボ用の送光レンズ12の夫々の焦点に配置された発光素子14には、発振器18の正弦波出力（5kHz）がドライブ回路19を経て供給される。これにより、AM変調された視準サーボ光が送光レンズ12を通って船台側の視準光学系の受光レンズ13に入射され、その焦点に配置された受光素子15に結像する。

一方、船台側の送受光ユニット11における送光用発光素子14からは、同じくAM変調された視準サーボ光が送光レンズ12を通して陸上局に向けて放射され、陸上局の受光レンズ13を介して受光素子15で受光される。

なお陸上局の送受光ユニット11から船台局へ送出された視準サーボ光が、船台局の反射器4で反射されて自局の受光系に戻って来て、サーボ系の妨害信号となる。これを防ぐために、船台局の視準サーボ光のAM変調周波数を3kHzにして、陸上局のAM変調周波数の5kHzと異ならせている。陸上局サーボ系は後述のように受信サーボ信号の周波数選択を行って、船台局からのサーボ光(3kHz)のみに応答し、自局の戻り光(5kHz)による妨害を排除している。

受光素子15は、例えば光スポットの原点からの位置を検出する二次元(X−Y平面)の半導体位置検出素子であってよい。この素子は方形受光面を持つフォトダイオードの四辺に4つの電極(X、Y二対)を設けた構造を有し、光スポットが当たった位置に生成された電荷が、光電流として各電極までの距離に反比例して受光面の抵抗層によって電圧分割されて各電極から取出されるように成されている。

第1図において、受光素子15の各電極の出力は、同調トランス20a及び同調コンデンサ20bから成る同調回路20で周波数選択(3kHzに同調)され、アンプ21a〜dを通り、検波器22a〜dで同期検波されて、受光位置に対応したレベル値のDCレベル信号に変換される。4局の検波出力は、上下(U、D)及び左右(L、R)の位置検出信号として、A/D変換器23でディジタル値に変換されてから、バス24を介してシステムコントローラ24内のマイクロプロセッサに取込まれる。

マイクロプロセッサ内では、U、D、L、Rの位置検出データから受光素子15の受光面における受光スポットのX−Y座標位置が演算される。システムコントローラ25はこの座標位置データに基づいて各軸のモータドライブ回路26X、26Yに駆動パルスを導出し、これによりX軸、Y軸のギヤモータ9、10が夫々駆動される。受光素子15からモータ9、10に至るサーボループは、受光素子15の受光スポットが受光面のX−Y座標の原点に位置するように動作する。サーボが利いている状態では、陸上局及び船台局の視準光学系光軸が一致する。この結果、陸上局の光波距離計3の光軸が船台局の反射器4に正しく向けられて、測距が可能となる。

なお船台局には同様の視準サーボ系が設けられているので、対向する二局でお互いに視準し合うことになる。

各局の視準装置2の光軸の向きを微調する手段が設けられている。第1図ではこの微調手段はジョイスティック27であるが、各X−Y軸のモータ9、10のギヤ系に微調つまみを設けてもよい。ジョイスティック27のX方向及びY方向の操作に対応した電圧出力がA/D変換器28を介してシステムコントローラ25に送られ、コントローラ25からモータドライブ回路26X、26Yに微調用駆動パルスが導出されて各モータ9、10が微動される。従ってオペレータは例えば光波距離計3の視準望遠鏡を覗きながらジョイスティック27を操作して相手局を視準する。視準が完了した時点でサーボのスタート釦を押すと、上述の視準サーボが始動し、その後は船台のゆれや移動に追従した自動視準が行われる。

受光素子によって検出された光軸のずれ等は、システムコントローラ25のバス24に連なる表示器29によって表示される。表示器29は例えばCRTであって、そのXY座標表示におけるスポット29aが、X軸(水平方向)及びY軸(垂直方向)の原点からのずれを示す。CRTのバー表示29bが受光素子15の総合受光レベル(受光強度)を示す。

視準状態で光波距離計3の回路部30が作動すると、対物レンズ5の焦点位置に置かれた送受光ユニット31により、約15MHz(AM)の測距光の発信及び測定点からの反射光の受信が行われる。これらの発信光と受信光との位相差が回路部31で測定されて、それに基づいて局間距離が算出される。距離データは、インターフェース32、バス24を通じてシステムコントローラ25に転送され、更にモデム33を通じて船台局に送出される。

陸上局と船台局との間の自動視準用の送光光路及び受光光路を双方向光通信路としても利用している。即ち、モデム３３の送信端子Ｓからの出力は、ＦＭ変調器３４に導入され 5.5MHz のキャリアが送信データでもってＦＭ変調される。ＦＭ出力はドライブ回路３５を介して送信用発光素子１４′に与えられる。この発光素子１４′からの送信データ光は、送光レンズ１２を通して船台局に送られる。

一方、船台局は同様なモデム３３や送信用発光素子１４′等を備えていて、送信データ光を陸上局のサーボ用受光光路に乗せて送信して来る。この際、既述の視準サーボ系と同じ理由により、船台局からの送信光のＦＭキャリアを５ＭHz にして、陸上局からの送信データのキャリア周波数5.5 MHz と異ならせている。これにより距離計３の反射光路が存在することに起因する陸上局側の自己漏話を無くしている。船台局からの送信データは例えば気圧、温度等の測距用の物理条件補正データである。

船台局から送られて来たデータ光は、受光レンズ１３を通してサーボ光と共に受光素子１５によって受光される。データ信号は受光素子１５を構成する平面ダイオードのアノードからサーボ信号と分離して取出される。上記平面ダイオードのアノードＡにはデカップリングコンデンサ３６を設けた電源ラインからトランス３７の１次巻線３７ａを通して電流が供給される。この１次巻線３７ａのインダクタンスを１μＨ程にすると、５ＫHz のサーボ信号に対しては、インピーダンスが0.03Ω以下であり、挿入損失は無視できる。従ってデカップリングコンデンサ３６を利かせて、サーボ周波数で変調されない直流を受光素子１５のアノードＡに供給することができる。

一方、５ＭHz のＦＭデータ信号に対しては、１次巻線３７ａのインピーダンスは３０Ω程になって、その挿入損失分を２次巻線３７ｂから取出すことができる。取出されたデータ信号はアンプ３９を介してＦＭ復調器４０に導出される。なお既述のように５．５ＭHz の発信データ信号の自己漏話を無くすために、トランス３７の２次巻線３７ｂに同調コンデンサ３８を結合して、５ＭHz の受信データ信号に同調させてある。

ＦＭ復調器４０の出力は、モデム３３の受信端子Ｒに入力され、デコード処理されてからシステムコントローラ２５に与えられる。システムコントローラ２５では、受信データを用いて測距データの補正等が行われる。

第５図は送光レンズ１２に連なるＬＥＤ等の発光素子１４、１４′の駆動回路例を示す。（Ａ）は第１図の実施例に対応し、グループ分けされた発光素子１４、１４′はグループごとに並列に接続されて、発振器／ドライブ回路１８、１９及び変調器／ドライブ回路３４、３５によって駆動される。（Ｂ）は、視準サーボ系が無く、例えば固定局間でデータ送受信のみを行う場合であって、全部の発光素子１４を並列接続して、送信データを入力とする変調／ドライブ回路４２の出力でもって各素子を駆動する。なおＡ、Ｂの何れの場合でも、発光素子１４を直列に接続してもよい。

第６図（Ａ）は発光素子１４の駆動回路の別例を示し、送信データ信号とサーボ信号とを変調／ドライブ回路４２に供給して、多重変調し、並列接続の発光素子１４を駆動する。サーボ光（５ＫＨＡＭ）とデータ光（５．５ＭHz ＦＭ）とは、第６図（Ｂ）に示すように振巾方向に５０％ずつの変調度で多重されて送光される。

第７図は第１図の送光レンズ１２及び発光素子１４として使用できるレンズ付ＬＥＤを示す。このＬＥＤはレンズ４３を備えるので、このような複数個のＬＥＤを受光レンズ１３の周囲に環状に直接配設することができる。発光角が５°、１２°３０°位のものを市販品として種々入手し得るので、距離性能に応じて適当なものを選択すればよい。場合によっては送光レンズ１２と組合わすことができる。また発光素子１４の数を増すことも容易である。

第８図は送受光ユニットレンズ配置の別の例を示す。この例では、受光レンズ１３と並べて、光波距離計の対物レンズ５を別々の鏡筒内に軸平行

に配置してある。各レンズ１３、５の周囲に小口径の送光レンズ１２を略環状に配し、これらをサーボ光及びデータ光の送光用に用いている。送光レンズ１２の１つ又は複数を、光波距離計の送光用（１５MHz AM）としてもよい。

第９図はサーボ光学系と光波距離計の光学系とを共用した例の光学系を示す。サーボ光は複数の発光素子１４から環状配置の送光レンズ１２を介して送光される。発光素子１４の１つを光波距離計の光源として用い、送光レンズ１２から船台局の反射器に向けて送光する。船台局からのサーボ光（５KHz AM）及び反射器からの測距離反射光（１５MHz FM）は、大口径の受光レンズ１３で集光され、受光素子１５（位置センサー）に結像されると共に、結像空間に挿入された半透鏡４４を介して光波距離計の受光素子４５に入光される。従ってこの例では視準サーボ光学系と光波距離計の光軸が一致（共通）するから、各光軸を平行にする調軸機構が不要である。

サーボ光と測距光とは変調周波数が異なるので、処理回路に周波数選択手段を設ければ、相互に干渉することはない。また半透鏡４４の挿入損失を軽減するために、サーボ光と測距光との波長を例えば９００nmと１１００nmとに分けて、半透鏡４４の代りに波長１１００nm以上を効率良く反射し、それ以下を損失無く透過させるカットフィルタ又はダイクロイックミラーを用いるとよい。

〔発明の効果〕

本発明は上述の如く、受光レンズ１３を大口径にする一方で小口径送光レンズを受光レンズの周囲に環状に多数配した構成であるので、光学系が小形でしかも受光感度及び送光出力を夫々増強でき、より遠距離の送受光が可能となる。また多数の送光光軸の幾何的平均が受光光軸と一致し、送／受の光軸の不平行度が多数の平均により緩和される。従って調軸機構を設けなくても、見かけ上光軸平行度を上げることができ、簡易な構造で遠距離の送受光性能を一層高めることができる。

４．図面の簡単な説明

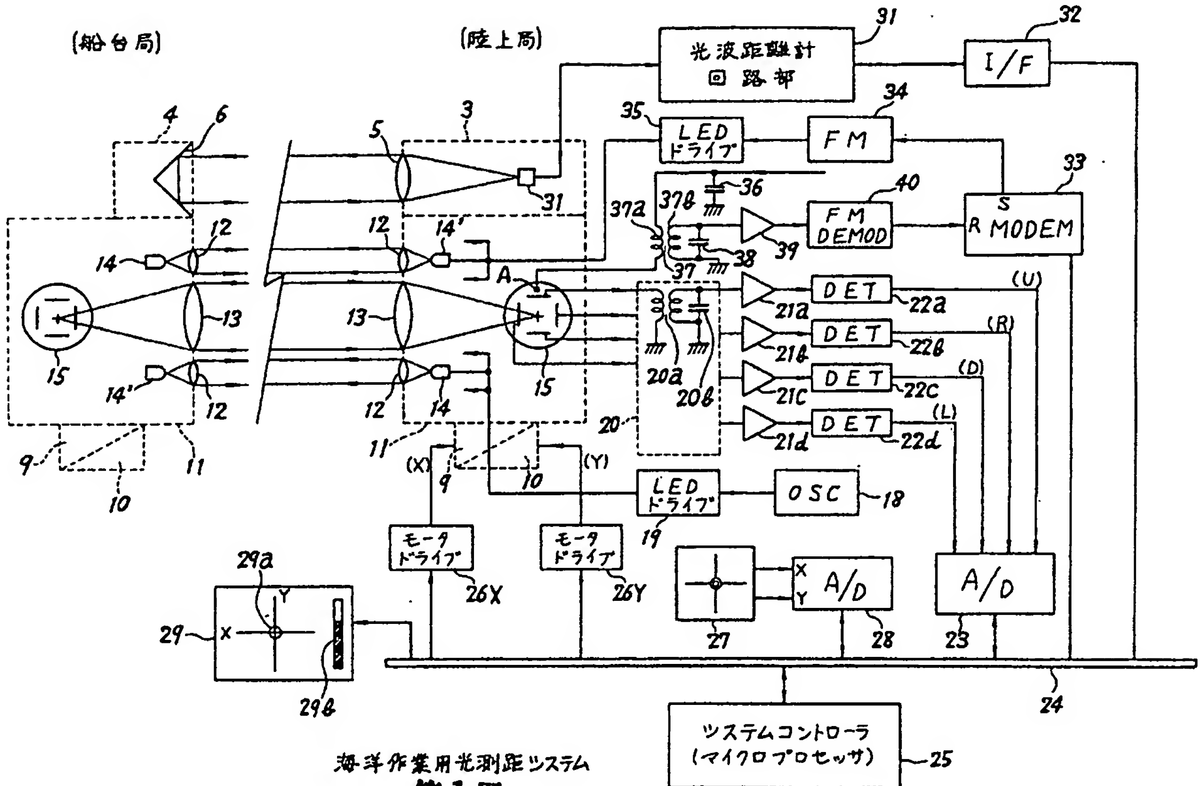
第１図は本発明の一実施例を示す海洋作業用光測距システムの全体ブロック図、第２図及び第３図は夫々陸上局及び船台局の各測距装置の正面図、第４図は送受光レンズの配置例を示す送受光学系の正面図、第５図は発光素子の駆動回路図、第６図は発光素子の駆動回路の別例と送光信号の波形を示す回路図及び波形図、第７図は発光素子及び送光レンズとして使用できるレンズ付ＬＥＤの概略図、第８図は送受光レンズの配置の別例を示す光学系の正面図、第９図はサーボ光学系と測距光学系の光軸を共用した例の光学系の略線図である。

なお、図面に用いた符号において、

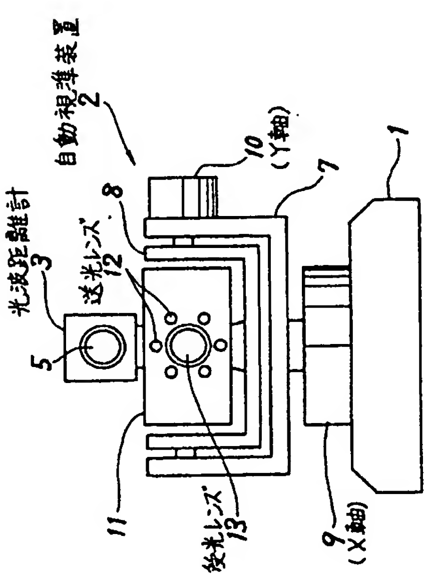
2……………………自動視準装置
3……………………光波距離計
4……………………反射器
5……………………対物レンズ
6……………………コーナキューブプリズム
7……………………水平架腕
8……………………垂直架腕
9……………………Ｘ軸ギヤモータ
１０………………Ｙ軸ギヤモータ
１１………………送受光ユニット
１２………………送光レンズ
１３………………受光レンズ
１４………………発光素子
１５………………受光素子
３３………………モデム
３４………………ＦＭ変調器

である。

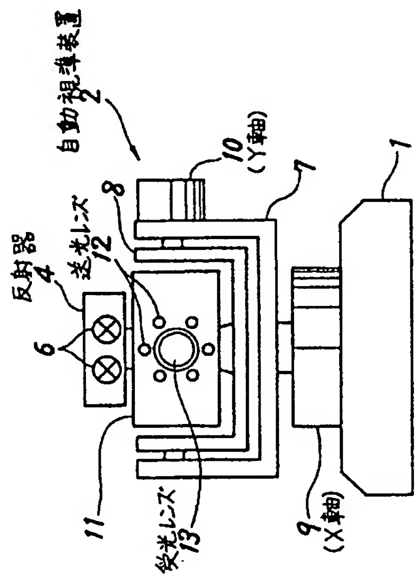
代　理　人　　土　屋　　　勝



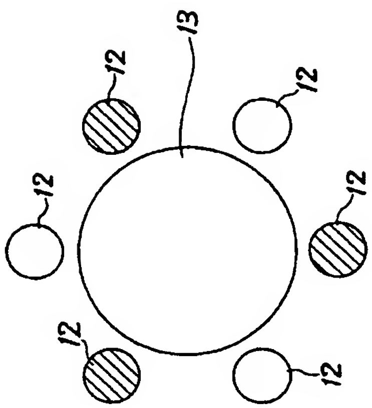
海洋作業用光測距システム
第1図



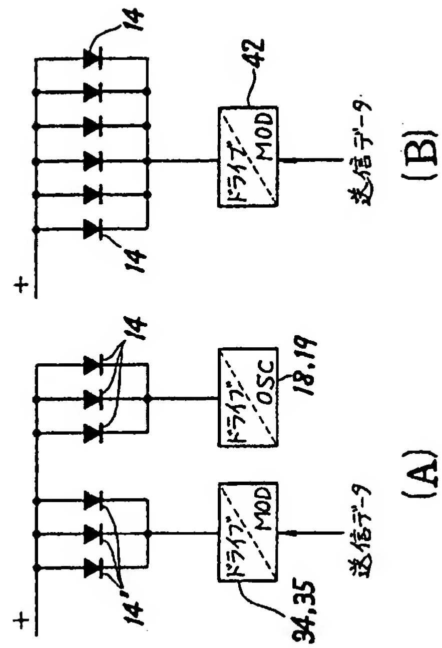
陸上局
第2図



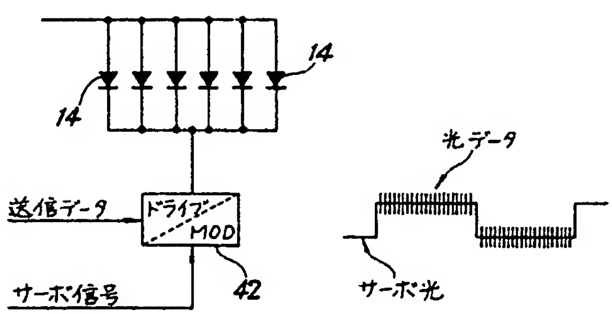
船台局
第3図



送受光対物レンズ
第4図

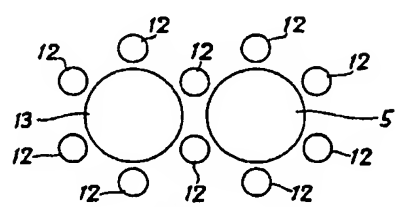


LEDの駆動回路
第5図

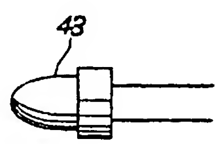


(A)　(B)

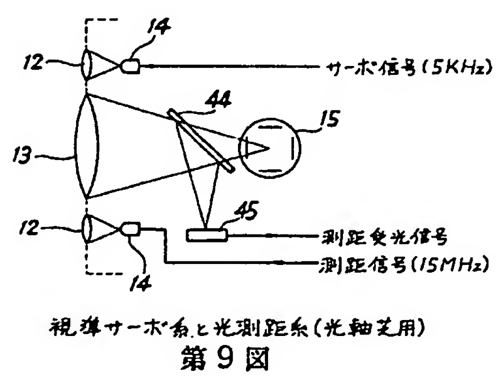
多重変調方式
第6図



送受光レンズ
第8図



レンズ付 LED
第7図



視準サーボ系と光測距系（光軸芯用）
第9図

(19)

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(71) Applicant: **OPT:KK**

(72) Inventor: **NARUTAKI YOSHIISA**
SATO KATSUTOSHI
OOURA HITOSHI
NUMAZAWA NORIO
HAYASHI KOICHI
MACHIDA MISAO
KUSUMOTO SHIGEHI
SEKIKAWA HARUMI(

(74) Representative:

(54) LIGHT TRANSMITTER-RECEIVER

(57) Abstract:

PURPOSE: To realize the transmission and reception of light in a distance longer than ever, by arranging a great number of transmission lenses with small diameters in the neighborhood of a reception lens annularly while the reception lens is formed as a lens with a large diameter.

CONSTITUTION: The titled device is equipped with the reception lens 13 with the large diameter provided with a light receiving element 15 on an optical axis, the transmission lens 12 with the small diameter, plural sets of which are arranged in the neighborhood of the reception lens 13 annularly and provided with a light emitting element 14 on the optical axis, and a transmitter-receiver connected to the light receiving element 15 and the light emitting element 14. Therefore, it is possible to increase light receiving sensitivity with comparatively simple constitution and by forming the reception lens 13 larger, and to easily increase a light transmission output. Also, since a great

transmission output. Also, since a great number of transmission lenses 12 are arranged along a concentric circle around a light receiving optical axis, it is possible to respond with an average transmitting optical axis. Consequently, even when the deviation of an angle between the receiving optical axis and an individual transmitting optical axis exists to a certain extent, the difference of the angles is offset by averaging a great number of optical axes, and an average transmitting optical axis coincides with the receiving optical axis. In such a way, the distance margin of the transmission and reception of the light can be extended.